HICKOK

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INSTRUCTION MANUAL
for

DIGITAL MEASURING SYSTEM

— MAIN FRAME —
the model DMS-3200P

THE HICKOK ELECTRICAL INSTRUMENT CO.

2490-610

DMS-3200P
WITH
DP100 INSTALLED

DMS-3200P
DIGITAL MEASURING SYSTEM

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HICKOK

DIGITAL MEASURING SYSTEM

WARRANTY

The Hickok Electrical Instrument Company warrants Digital Measuring System instruments of its manufacture to be free from defects in material and workmanship for one year (12 months) from the date of original purchase. Any instrument found to be defective during this period may be returned, transportation prepaid, to the factory for repair, or at our option, replaced without charge.

This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons, or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced or removed. Neither shall the warranty apply where a warranty registration card has not been properly completed and returned to us promptly after purchase. This warranty is in lieu of all other warranties whether expressed or implied.

RETURNING EQUIPMENT FOR REPAIR

Before returning any equipment for service, the factory must first be contacted, giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Upon authorization, this equipment should be forwarded directly either to the Hickok factory address at 10514 Dupont Avenue, Cleveland, Ohio, 44108, or to a designated service station in your locality.

19120-154

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SPECIFICATIONS

Power Source: 115 volt/230 volt ± 10%, 47 to 400 Hz AC, 30 watts maximum (16 watts with typical plug-in)

Isolation from 3rd Wire Ground: 1500 volts minimum, (10^9 ohms minimum leakage resistance)

Construction: Fully Transistorized; with Integrated Circuits. (No tubes or relays)
High Quality Glass Epoxy (G-10) Printed Circuit Boards
Die Cast and Extruded Chassis

Number of Digits: 3 (overrange capability determined by plug-in)

Readout: NIXIE* Type Gas Tube Readout with either buffered or non-buffered operation, decimal points (controlled by plug-in), ± sign (for appropriate plug-ins), wrong polarity indicator (for use with DC voltage measurements) Overrange indicator (to warn of greater than full scale reading)

Printer Output: Ten line decimal, 3 columns numerical data plus 1 column accessory data: decimal points, wrong polarity, overrange, polarity

Output Levels: 0 state level +.2 volts. 1 state level +1.5 volt. For accessory column voltages consult schematic, page 17, and detailed description of output page 7. Maximum available current 300μA per output line.

Print Command: 3 available at time of reset

1. positive going pulse 5 μ sec long going from +.2V to +3V
2. negative going pulse 1 μ sec long going from +3V to +.2V delayed from 1 by 1.5 μ sec.
3. positive going pulse 1 μ sec long going from +.2V to +3V delayed from 1 by 1.5 μ sec.

Holdoff Voltage: +1.5V to +5V from source impedance less than 1KΩ.

Counter Response: Pulse rates up to 5×10^6 PPS

Operating Temperature Range: 0° to 50° C

Size: 9-5/8"w x 6-7/8"h x 12-7/8"d (including handles)

Weight: 10 lbs.

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Figure 1. DMS-3200P Digital Measuring System Main Frame

I
CHARACTERISTICS

General

The DMS-3200P Digital Measuring System Main Frame is designed to be used with DP series Plug-ins. The main frame system is the mother unit for a series of plug-ins which enable measurement of almost any parameter capable of measurement simply by interchanging the plug-in units. It contains the readout devices, which are numerical neon lamps (NIXIE*tubes), sequential counting, buffering and readout control circuits, and regulated power supplies which power both the main frame and the plug-in which is being used.

The plug-in is inserted into the main frame by slipping it onto the runners provided in the access port of the main frame. The locking shaft should then be turned until the plug-in is securely held into the main frame.

CAUTION: The power should be turned off when removing or inserting plug-in units.

Controls

The only control contained on the front panel of the DMS-3200P is the power switch. No pilot lamp is provided because the readout tubes light immediately upon application of power. On the rear panel is a slide switch which chooses either direct counting readout (non-buffered) or buffered operation (non-blinking display) in which the counting process does not appear visually in the readout.

Turn On

The circuits of the main frame are such that upon application of power several digits of a decade may be displayed simultaneously. A reset pulse will correct this condition. From that time on the unit will operate normally.

Power Cable

The three conductor power cable supplied with the main frame terminates in a polarized three-prong male plug. The third contact is an offset round pin added to a standard two blade plug. This contact does not ground the instrument case. It is connected only to the primary shield of the transformer.

Power Source

This instrument is connected for 115 volt operation in production. For 230 volt operation the connections as shown in the lower left hand corner of the schematic (figure 11) should be made. No fuse change is required.

Printer Output Connector

The printer output connector is located on the rear panel. The printer output connector provides three columns of 10-line decimal data output plus one column of accessory data including decimal points, polarity wrong polarity and overrange information. It also contains print command output and inhibit input. The outputs from this connector can be used to run such items as printers or controllers. The Hickok PR4900 printer plugs directly into this output and will print out information contained in the main frame.

II
CIRCUIT DESCRIPTION

Main Frame Counter and Display

The main function of the DMS-3200P is the numeric display of the number of pulses entered. The display utilizes NIXIE* type neon glow numeric tubes. Three of these tubes allow up to 999 pulses to be entered and read directly. The 1000th pulse is used to turn on an indicator light marked "Overrange" at the same time the number "000" is displayed. Any number of pulses may be entered and the DMS-3200P will display the last three digits of this number and turn on the overrange light if the number exceeds 999. These pulses may be counted and displayed in two ways. The pulses may be counted and stored. Upon application of a pulse to the toggle input of the buffering flip-flops, the stored information in the counters will be transferred into the buffering and readout circuits for viewing. The alternative method is to count and transfer into the buffering as each count registers. The latter method is called the non-buffered mode of operation. The meaning of the overrange light will depend on the particular plug-in used. Four decimal points are provided and numbered DS1 through DS4, from left to right. Their control and interpretation depend on the plug-in used. In addition to the above, a ± sign and an indicator marked "wrong polarity" are provided and controlled by switching in the plug-in. All the circuitry for accumulation (counting), buffering and display is on one printed circuit board, referred to as the main counter board.

The Counter

The task of accumulating the number of input pulses entered is performed by three cascaded decade scalers. Each decade scaler is composed of 5 RTL JK flip-flops interconnected as a switch-tail-ring counter. This ring counter passes on one output pulse for every 10 pulses entered. Since all three decades are identical, only the first will be examined. Figure 2 is a schematic of the counter without provision for display or buffering.

The blocks marked A, B, C, D and E are JK flip-flops. They have inputs called "clear" (c), and "set" (s), and two outputs "0" and "1". There is an input, "toggle", marked T and a "reset" input marked R. To describe their operation, we will call a "0" the presence of a voltage between 0 and +.3V, and a "1" is the presence of a voltage between +.7V and +3.6V.

The voltages designated as 0's or 1's may be either inputs or outputs. The symbol A_0 refers to the output level of the "0" side of the A flip-flop regardless of what the output level is; i.e., it may be that $A_0 = 0$, or $A_0 = 1$. Similarly, A_1 refers to the output of the "1" side of the A flip-flop, and B_0, B_1, C_0, etc. refer to the outputs of the corresponding flip-flops. Because these circuit blocks are flip-flops, it is necessary that if $A_0 = 0$ then $A_1 = 1$, and if $A_0 = 1$, then $A_1 = 0$.

The JK flip-flop operation may be described by:

1) A positive pulse at the reset input (i.e., R = 1) sets the flip-flop so that the "1" output is 0 (i.e., if R = 1, then $A_1 = 0$, B1 = 0, etc.)

2) If the set and clear inputs are both at 0, then a positive pulse at the toggle input will cause the flip-flop to change states when the pulse returns to 0; i.e., if C = 0, S = 0, $A_0 = 1$, and $A_1 = 0$, then the application of a toggle pulse will produce $A_0 = 0$ and $A_1 = 1$. Another toggle pulse will cause it to switch again to $A_0 = 1$, $A_1 = 0$, etc.

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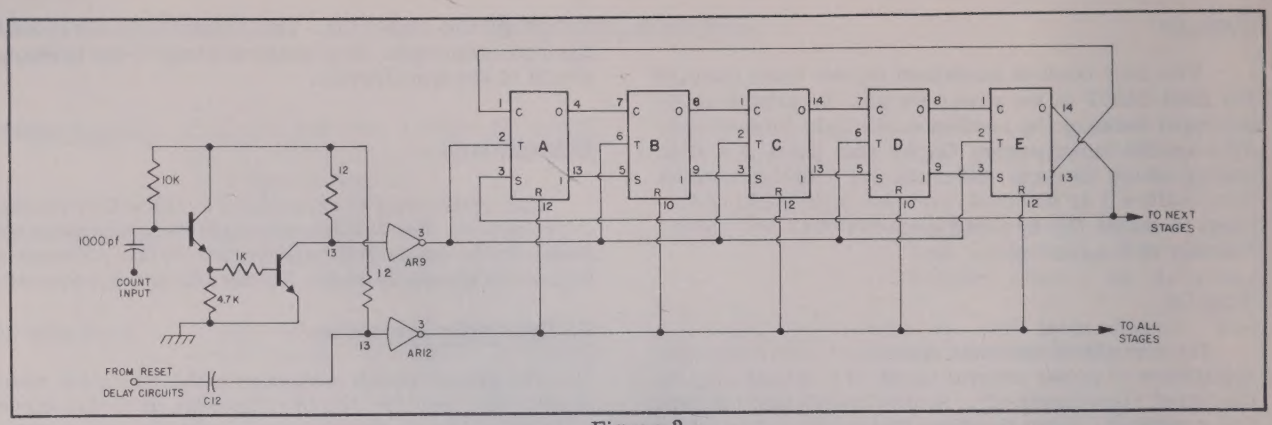

Figure 2

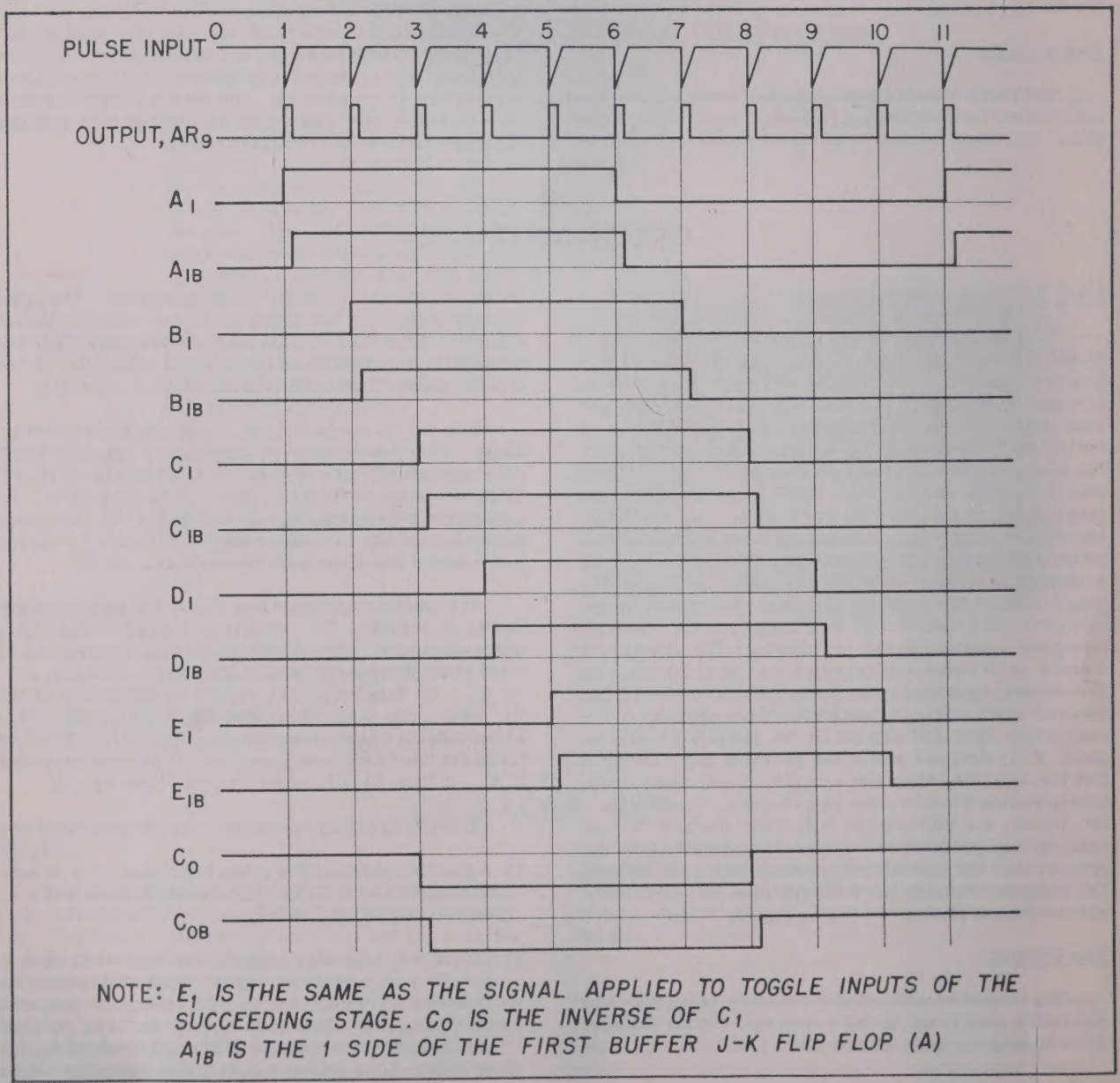

Figure 3

3) If either the set input or the clear input is 1 and the other input is 0, application of a toggle will cause the output states to match the set clear input state, regardless of the previous state (i.e., S = 1, C = 0, then $A_1 = 1$, $A_0 = 0$).

4) The outputs will remain unaffected by changes in the set and clear inputs provided there is no toggle pulse.

The circuit blocks AR9, AR10, AR12, and AR13, are circuits designed to provide the proper internal sequencing for buffered or non-buffered operation. These blocks also provide inputs and outputs for accessory equipment such as printers or controllers. Q43 and Q44 simply act as buffering elements to the input count line going to the plug-ins. They raise the input impedance of the main frame and invert the count signals coming in. Further routing of the count signals then depends on the mode of operation switch. In buffered operation, the count signals go only to the counting circuitry via AR9 (pins 3 and 13). In non-buffered mode operation, the count signals again go to the counting circuitry via AR9 (pins 3 and 13), and also go to AR10 (pins 5, 6 and 7). The count signals then go to AR10 (pins 1, 2 and 3), AR10 (pins 8, 9 and 10), AR9 (pins 5 and 6), and to the toggle inputs of the buffer flip-flops. Therefore with each count pulse entering the counting circuits the state of the counter is transferred into the buffering circuits.

The buffers AR12 and AR13 are used to delay the reset signal entering the main frame. The initial reset appearing at the output of AR13 which occurs simultaneously with the incoming reset signal is transferred through AR10 (pins 12, 13 and 14) to AR10 (pins 1, 2 and 3), AR10 (pins 8, 9 and 10), AR9 (pins 5 and 6) to the toggle input of the buffer flip-flops. This then transfers the reading in the counting circuits into the buffering circuits and hence into the display. The output of AR13 (pins 3 and 13) is a positive going pulse. On the negative edge of this pulse it biases AR13 (pins 5 and 6) off, thereby creating a positive pulse on the output of AR13 (pins 5 and 6). This positive pulse is of about 1μs duration. On its falling edge it will shut off AR12 (pins 3 and 13), creating a positive pulse on the output of AR12 (pins 3 and 13). This positive pulse, which is delayed from the initial pulse appearing on the output of AR13 (pins 3 and 13), puts a "1" on the R input of the counting JK flip-flops. This resets all the counting JK flip-flops back to 0. As pointed out earlier, the reading previously in these counting flip-flops was transferred into the buffering flip-flops by the initial reset itself, thereby allowing the buffering flip-flops to "remember" the counter state when the toggle was applied to their inputs. In buffered mode operation, the reset stops at the output of AR10 (pin 5) because the mode of operation switch is in the buffered mode position. In non-buffered operations, the reset pulse on the output of AR12 (pin 3) is transferred to AR12 (pins 5 and 6), then to AR10 (pins 5, 6 and 7), AR10 (pins 1, 2 and 3), AR10 (pins 8, 9 and 10), AR9 (pins 5 and 6), and hence to the toggle inputs of the buffering JKs. This transfers the new state now in the counting flip-flops, which is 000 "overrange" off, to the buffering flip-flops, hence making their output state 000 and hence the reading 000.

The outputs and input to the printer output connector are 4: there are 3 resets available as outputs for control of printers for controllers and 1 input is available on pin 2, which is the toggle inhibited input. By applying a positive voltage of +1.5 volts on pin 2, the output state of AR10 will always be 0, hence no signal will be transferred through AR10 (pins 1, 2 and 3) to AR10 (pin 10). Hence, no toggle input can be applied to the buffering flip-flop inputs in order to change their state to match the counting flip-flop inputs. This is used to assure that there will be no change of state in the output circuits while the peripheral equipment, such as the printer or controller, are determining the state of the main frame circuitry in order to perform their function.

The Buffering

The buffering consists of one JK flip-flop for each JK flip-flop in the counting circuit. These are connected such that the Set input of the buffering flip-flop is connected to the 1 output of the counting flip-flop, and the Carry input of the buffer flip-flop is connected to the 0 output of the counting flip-flop. With the operation of a JK flip-flop as described above in mind, it is easy to see that a toggle to the toggle input of the buffering JK flip-flops will enable them to assume the same state as the counting JK flip-flops. If no toggle is applied to the buffer JK flip-flop toggle inputs, the buffer JK flip-flops will retain the state they assumed at the previous toggle input regardless of the state of counter, thereby remembering the state of the counting circuitry when the last toggle input was applied to the buffering flip-flops. The states of these buffering flip-flops represent a number. Display circuitry decodes these states to a decimal number and turns on the appropriate driver to turn on the appropriate number in the readout tube.

The Display

From the foregoing discussion it can be seen that the five-stage ring counter has a unique state which corresponds to the last digit of the number of pulses put in; for example, after starting from reset, 467 pulses into the counter of figure 2 will produce the state shown in figure 3 at the 467th pulse, and in the process, 46 pulses will be put into the succeeding counter. That counter in turn will be in the 6th state (figure 3 at the 46th pulse) and it will pass on 4 pulses to the last counter, moving it to the 4th state. To display the number 467, we must transfer the counter states to the buffer flip-flops. This can be done by two methods, depending on the mode of operation. In non-buffered mode of operation, the pulses will be transferred into the buffering flip-flops directly as the counter flip-flops change state. In buffered operation, a toggle pulse must be fed to the input of the buffering JK flip-flops in order that they may assume the state of the counting flip-flops. After the count information has been transferred from the counting flip-flops to the buffering flip-flops, we must then display the number 467. To display the number 467, we need to light up a 7 from the first counter, a 6 from the second, and a 4 from the third counter. The following example is worked out in detail to illustrate the logic involved.

The schematic, figure 11, shows three NIXIE* tubes, all connected alike. V1, for example, is operated from the first counter and buffering flip-flops and functions as the units (right-most) digit in the display. When a 1 is presented to Q7 it conducts and the 7 digit glows. Consequently, we need to present a 1 to Q7 if, and only if, the state of the counter is that illustrated in figure 3 after the 7th pulse.

This is done by connecting NOR gates to the appropriate outputs of the buffering flip-flops. A NOR gate has the property of having a 1 output if, and only if, both inputs are 0. From figure 3 we see that C_0 and B_1 are both 0 only when the counter is in state 7. Consequently, the outputs C_0 and B_1 are connected to a NOR gate and the output of that gate drives Q7. The connections for the other digits are shown in a table in figure 11. The logical process is similar and all three decades are connected in the same manner.

It should be noted that a counter of the type used here can have stable states other than those shown, and it is quite possible that more than one digit per NIXIE* tube may light. This commonly occurs when the DMS-3200P is first turned on. However, when a reset pulse is entered, the counters return to the 0 state. In non-buffered operation the display will immediately return to the 0 state. In buffered operation it takes a second reset pulse to transfer the reading in the counters to the buffering flip-flops. Therefore, to return the display to a reading of 000, it will take two resets. However, after application of the first reset pulse, the counter is returned to the 0 state and thereafter the states illustrated in figure 11 are the only ones possible.

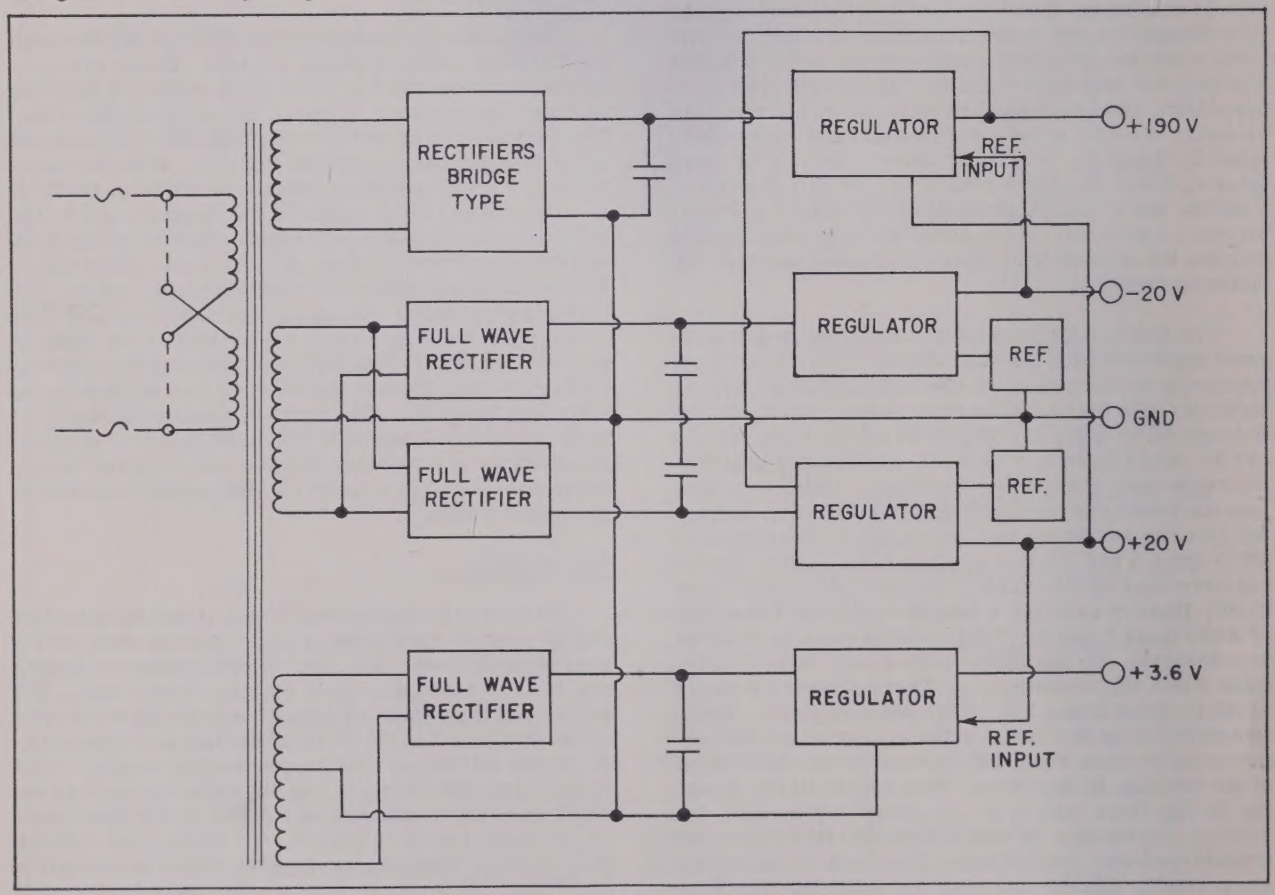

Figure 4. Power Supply Block Diagram

Power Supplies

There are four dc power supplies all regulated and referenced to a common ground. They provide power for the Counter and Readout as well as the plug-ins. One power transformer is used. It has a split primary so that either 115V or 230V power line may be used. The schematic, figure 11, shows the connections necessary for either power line voltage. Two electrostatic shields are present: the first between the primaries and core, the second between secondaries and core. The primary shield is returned to the third (green) wire ground. The secondary shield is connected to the main frame case. Both sides of the line are fused with 1/2 amp slo-blo fuses. The +20V supply consists of a center tapped secondary winding providing about 39.4V rms, a full wave rectifier, a filter capacitor, and a series regulator referenced by

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means of a 19V zener diode. The series regulator consists of a high gain feedback amplifier of conventional design. The passing transistor Q6 is mounted on the rear panel which acts as a heat sink. Short circuit protection is provided by limiting the base current to the passing transistor. If the supply current is excessive, the voltage dropped across R11 causes Q7's base current to be shunted into the load, thus depriving Q6 of its base current and this limits the total current delivered. Note that the +190V supply provides the collector current for Q8 and the base current for Q7. If the +190 supply fails, the +20 supply will also fail. The +20 supply is adjusted to 20.0V ±0.1V and is capable of providing 170 ma with less than 5mV average ripple.

The -20V Supply

The -20V supply is essentially the same as the +20V supply except that p-type transistors are used instead of n-type. This supply also is adjusted to -20.0V ±0.1V and is capable of providing 30ma with less than 10mV average ripple.

The +190V Supply

The +190V supply uses a full wave bridge driven from a high voltage winding of the transformer. The filtered dc is also regulated with both the passing (Q3) and shunt (Q4) transistors mounted on the rear panel. This regulator is controlled by a precision voltage divider referenced to the -20V supply. It is protected against overloads in the same manner as the +20, and -20 supplies. It will supply 30ma at +190V ±2%. The +3.6V supply utilizes a low voltage winding on the transformer and a series regulator which is referenced to the +20V supply. It is protected against overload simply by limiting the maximum base current to the passing transistor. It will supply up to 1 amp.

Printer Output

The printer outputs are actually data outputs which provide external access to the data stored in the main frame counting and buffering circuits. These outputs, available at the rear "Printer Output Connector", are used as driving signals for such items as digital printers or digital controllers. Also included are a series of control signals which enable the external equipment to determine the proper time to initiate their cycle.

The following data is available at the Printer Output Connector:

1) Digit Information - These outputs are taken directly from the outputs of the NOR gates connected to the tube drivers. There is an output for each number in each tube. The output associated with a particular number will have from +1 volt to +1.5 volts on it when the number is turned on. The number outputs which are not on will have less than +0.4 volts present on the output terminals. The maximum load which can be applied to any number output is 3.3KΩ.

2) Overrange Information - This data has inverted characteristics to those of the digital data output lines: i.e., when the "overrange" light is on the output is low (less than +0.4 volts) and when the light is off the output voltage will be from +1.0 volts to +1.5 volts. Again, the maximum load on this line is 3.3KΩ.

3) Overspill - This is essentially the output of the third decade of the main frame. The output of this line will go from the "1" to the "0" level each time the counters step from the 999 state to the 000 state. The output levels and loading are the same as for the digit data lines, maximum load 3.3KΩ.

4) Decimal Point and Polarity - These outputs have characteristics distinctly different from the digit data output lines. Consulting the Schematic, page 17, will provide a better understanding of the signals available on these lines. A low level (0 volts) indicates an "on" condition. A high level, (60 volts) indicates an "off" condition. Note that for the polarity indication both lines, corresponding to horizontal and vertical bars, are low for a + sign, while only the horizontal bar line is low for a negative indication.

   The decimal points are lettered A, B, C, and D. These refer to the following locations in the readout:

   A - XXX.

   B - XX.X

   C - X.XX

   D - .XXX

   When "reading" the information on these lines, one must take care not to load them to the point that the decimal point or lights associated with the + and - sign are turned on when they should not be, in the visual readout of the DMS-3200P. This will insure that the visual readout is not impaired by the presence of the peripheral equipment. The minimum recommended resistance connected to any line is 1.5 megohms.

5) Wrong Polarity - This output has essentially the same characteristics as the digit data outputs. The output level is from +1 volt to +1.5 volts when the light is turned on, 0 volts when the light is off. The output may be loaded with a 3.3 K ohm load.

6) Print Command, Storage Toggle, Delayed Reset, Direct Reset - Before attempting to use these signals a thorough understanding of the theory of operation is imperative. The four signals ("print command", "storage toggle", "delayed reset", "direct reset") are simply the same signal, the "print command" and "delayed reset" being delayed from the "direct reset" and "storage toggle" by about 1.5μ second.

   a) The "direct reset" is the reset taken directly from the plug-in. This is a negative-going pulse of at least 3 volts amplitude with varying width, depending on the plug-in being used. The maximum load which may be applied to this line is 3.3 KΩ.

b) The "storage toggle" is the pulse which transfers the reading in the counters to the buffering JK flip-flops. This is a positive pulse of approximately 5μ second duration, the beginning of which occurs simultaneous to the leading edge of the direct reset pulse. The width of this pulse will depend in part on the plug-in used. The maximum load on this output is 2.2 KΩ.

c) The "print command" and "delayed reset" outputs occur at the same time and are delayed from the end of the "storage toggle" pulse by about 1.5μ seconds.

The "delayed reset" consists of two pulses: a positive pulse, then a negative pulse, separated by about 1.5μ seconds. The negative pulse will occur about 1.5μ seconds delayed from the "storage toggle" pulse. The pulses will be 1 volt to 3 volts high. Maximum load on this output is 2.2KΩ.

The "print command" output is a 1μ second positive pulse of from 1 to 3 volts in amplitude. This will be delayed from the "storage toggle" pulse by about 1.5μ seconds. The maximum load which may be used on this output is 500Ω.

7) Reading Inhibit - This is an input to the DMS-3200P. By applying +1.5 volts from a 500Ω source impedance supply, the toggle which transfers the reading from the counters to the buffering JK flip-flops is inhibited. This prevents the outputs to the peripheral equipment from changing while the peripheral equipment is proceeding through its cycle (example - an external printer will not be affected during its physical print operation). Applying this level to the "reading inhibit" input prevents only the buffering and display circuitry from changing states; it does not affect the counters. Therefore, while the "reading inhibit" is "high" (+1.5 v), the counters will continue to count. This reading will be transferred into the display at the time of the next buffer storage toggle pulse. The "reading inhibit" operates both in the buffered and non-buffered mode of operation.

8) Ground Connections - Three grounds are available on the Printer Output Connector. The three grounds are chosen such that spurious signals which may be present on the ground strings of the DMS-3200P will not interfere with the signals on the outputs.

a) The "decade ground" is used as the ground connection for the ten-line digit data outputs.

b) The "high current ground" is used as a ground connection close to the main frame power supply and plug-in grounds. This ground is used to ground the DMS-3200P to the peripheral equipment.

c) The "count ground" is used to reference the overspill pulse to ground.

The mating connector to the Printer Output connector is an Amphenol type 57/30500. It can be ordered from the Hickok Electrical Instrument Company as part No. 16525-229. Hickok series PR4900 printers are designed to be used directly with the DMS-3200P Main Frame. Consult the instruction book of the PR4900 for operating instructions and specifications.

Printer Output Connector SIGNAL OUTPUT Connections
(Pin 1 Upper Left Hand Contact and Pin 26 Lower Left Hand Contact When Viewed from Rear of DMS-3200P)

Connector Pin Number	Function	Connector Pin Number	Function
1	Print Command	26	Unused
2	Reading Inhibit	27	Unused
3	Overspill	28	Decimal Point A
4	Direct Reset	29	Decade Ground
5	Storage Toggle	30	High Current Ground
6	Unused	31	Count Ground
7	Delayed Reset	32	3rd digit #9
8	3rd digit #4	33	#8
9	#3	34	#7
10	#2	35	#6
11	#1	36	#5
12	#0	37	2nd digit #5
13	2nd digit #0	38	#6
14	#1	39	#7
15	#2	40	#8
16	#3	41	#9
17	#4	42	1st digit #9
18	1st digit #4	43	#8
19	#3	44	#7
20	#2	45	#6
21	#1	46	#5
22	#0	47	Wrong Polarity
23	Decimal Point B	48	Vertical Bar
24	Decimal Point C	49	Horizontal Bar
25	Decimal Point D	50	Overrange

III
SERVICE

General

No attempt should be made to service the DMS-3200P until the circuit description has been read and understood. Precautions should be taken to avoid a shock hazard since high voltages are present.

The first step is to determine whether the power supplies are functioning correctly. Malfunctions in the supplies will cause most plug-ins to operate incorrectly and can also affect the main counter.

Power Supplies

Access to the power supply and main counter board is accomplished by removing the 4 screws securing the rear panel and pulling it back so that the top cover plate may be slid out. At this time the bottom plate may also be removed. Care should be taken to avoid straining the harness and connections to the transistors mounted on the rear panel. The transistors themselves should not be disturbed unless replacement is necessary. With the top and bottom covers removed, the rear panel may be reinstalled. Generally, this arrangement grants sufficient access for service. If necessary, the power supply may be removed completely by removing 2 screws holding the power switch to the front panel, and 4 screws securing the power supply chassis to the side extrusions. Then the plug-in connector located underneath the chassis may be disengaged and now the complete power supply, rear panel and power switch may be removed as a unit.

A dummy load should be connected to the supplies when they are disconnected from the main frame counter board. Convenient values of resistors are:

Supply	Full Load	Low Load
+20V	-120Ω , 10 watts	1k
-20V	-750Ω , 2 watts	4.7k
+3.6V	-3.6Ω , 10 watts	10k
+190V	-63KΩ , 10 watts	120k

The voltages should be checked, preferably with a ±0.1% voltmeter. A DMS-3200P and DP-100 plug-in is good for this purpose. Ripple and noise can be observed with a sensitive (10mV/cm) oscilloscope or measured with a good wide band ac voltmeter having a 10mV full scale range.

The interrelations between supplies must be noted. The -20V supply is independent of all others. The +190V supply requires the -20V for its reference and the +20V for its reference amplifier to operate. The +20V supply needs +190 for its reference amplifier. The +3.6 supply needs the +20 supply for its reference. The following possibilities are listed assuming that the -20V supply is operating correctly:

+190 high, high ripple: Shorted Q3, open Q4, open Q5, low +20V
+190 low, high ripple: high leakage, Q4 shorted Q5, Q3 open
+20 high, high ripple: shorted Q6, shorted Q7, CR15 open
+20 low, high ripple: R13 open, CR15 shorted, CR12, 13, 14 shorted
+3.6 high: shorted Q2 or Q1 (or +20 high)
+3.6 low: Q2 or Q1 open (or +20 low)

Regulation from low load to full load is approximately .1% for the +20, -20, +190 supplies and about 5% for the +3.6V supply.

With the main counter board connected to the power supply, the supplies are able to deliver the following currents to a plug-in:

+20V	-	160ma
-20	-	30ma
+3.6	-	250ma
+190	-	15ma

Regulation will be lost if the current drawn by the plug-in exceeds these values.

After it has been determined that all supplies are performing correctly, the voltages of the +20 and -20 supplies may be adjusted by means of R14 and R17 respectively. These supplies have a slight positive temperature coefficient, and should be allowed to warm up for 15 minutes before final adjustment. Their output voltage should be set between 19.95 and 20.00 volts.

If any components are to be replaced, it is very important to observe the procedures outlined on page 12. A low soldering iron tip temperature is very important. If the iron's temperature is too high, the adhesive bond between the glass-epoxy circuit board and the copper laminate will be destroyed. Also, the copper laminate may be torn loose if much strain is applied. The recommended procedure for removing a component, if carefully followed, will result in clean, neat repairs without these difficulties.

Replacement of the power transistors mounted on the rear panel must be done carefully with a heat sink compound so that thermal conductivity is maintained while the transistors are electrically isolated. After installation, the insulation between transistors and rear panel should be checked by applying 1000V in series with a 2 watt 10MΩ resistor between the transistor (any lead) and the rear panel. Current flow should not exceed 1/10μ amp.

The Main Counter Board

It is important to check the power supplies as outlined above before attempting to service the Main counter board. All the following discussion assumes that this has been done. Access for trouble shooting may be obtained by removing the top and bottom cover plates as described above. Then, with no plug-in present, both the top and bottom of the main counter board are accessible. With no plug-in connected, the circuit ground should be connected to the case by placing a jumper from pin 1 of the power supply connector to the chassis. Problems may be isolated to either the display circuitry or the counter circuitry.

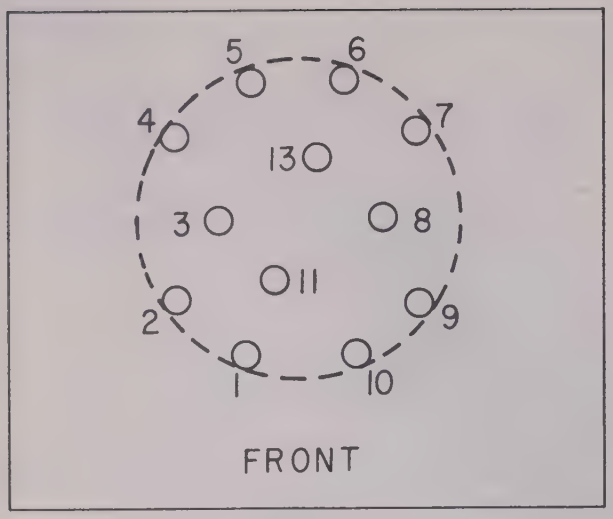


Figure 5.

Display

If a particular number refuses to light, then ground the appropriate socket pin on the readout tubes. The number should light. Figure 5 shows the pin layout as viewed from the bottom. If the number is still dark, replace the tube. The tube securing clamp is removed by gripping it in the middle and pulling up, bowing it slightly. If a particular number is lighted all the time, ground the base of the appropriate driver transistor. If the number remains lighted, either the tube has an internal short and should be replaced or the driver transistor is shorted and should be replaced.

If it has been determined that the display tube is good, and the driver transistor is not shorted, the trouble shooter must examine the corresponding NOR gate. Figure 6 illustrates the circuitry which drives the number 7 of the first digit.

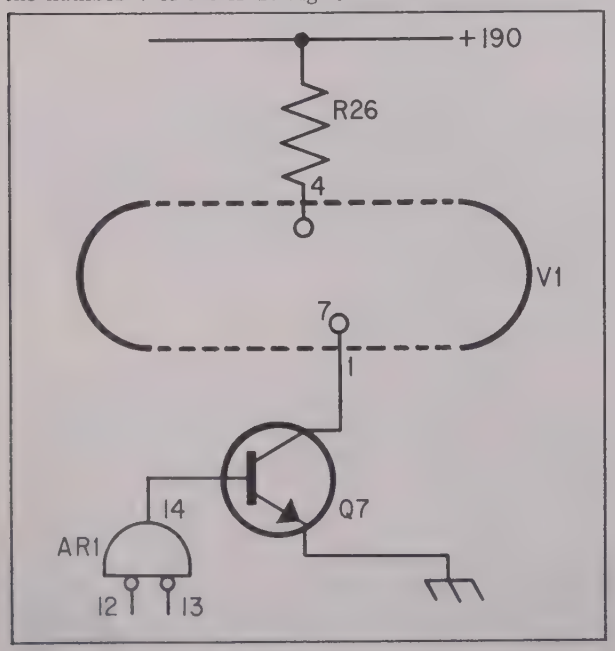


Figure 6.

Figure 10 shows where the integrated circuit package, AR1, is located. The small numbers indicate the package pin numbers. The schematic, Figure 11, shows package pin numbers throughout.

To check the NOR gate shown, both inputs (pins 12 and 13) should be connected to ground with jumpers. At this point, the voltage at the base of Q7 should exceed +0.6V and Q7 should saturate, lighting the number 7. The lighting of other numbers within V1 should be ignored. If there is trouble, replacing Q7 is much easier than replacing the package AR1 and should be done first.

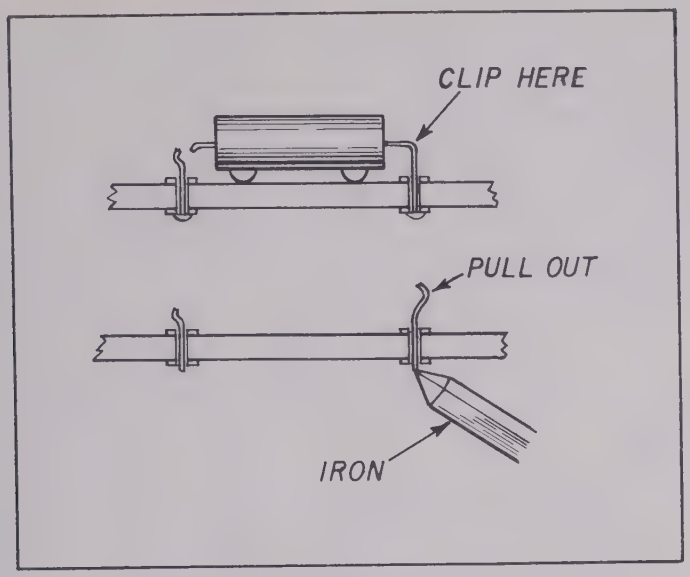
If the above checks show that the tubes, driver transistors and NOR gates are operative, troubles may be assumed to lie in the counters or buffer flip-flops. However, if a NOR gate has a shorted input, then this will disrupt the counter, and the above checks will not reveal this condition.

Counters and Buffer

The only approach to servicing the counters and buffer is to understand thoroughly the logic of their operation as outlined in "Circuit Description" above. The wave-forms shown in figure 3 are the best guide. Figure 11 identifies the package and pin numbers. Figure 10 shows their physical location. Patience and pencil and paper to write down observed states are necessary. For the purpose of examining the counter operation, the square-wave signal generator may be connected to pin 1 of the rear sub-panel connectors to provide a count pulse. A 3V peak-to-peak square wave is sufficient. A reset pulse may be generated by connecting pin 9 to the 3.6V supply through a 1k resistor and then shorting pin 9 to ground. Experience has shown that the best method to troubleshoot the counters and buffers is to operate the unit in non-buffered mode. With this in mind, all counter wave-forms apply to the buffering units as well. The buffered wave-forms will be delayed from the counter wave-forms by approximately the width of the count pulse.

The particular flip-flop may be checked for proper toggle operation. Short its set and clear inputs to ground. Make sure its reset input is at ground level and then turn on the square wave generators so that a toggle pulse is obtained. With an oscilloscope observe the 1 and 0 outputs: a square wave should be obtained from both at 1/2 the frequency of the signal appearing at the toggle input. However, if either output of the JK flip-flops is shorted to ground either by a short on the board or by a defective input to the following circuit element, the JK will not operate until the short is removed. If both sides of the flip-flops remain at 0 level, check for VCC of +3.6V on pin 11 of the package. If one side remains at 0 level while the other side performs normally, replace the package. If both sides remain at a 1 level, check for an improper ground connection to pin 4. In all cases, the service man should attempt to replace a package reluctantly, and

only after all other alternatives have been explored. There will be cases where it is impossible to determine precisely which package to replace and one must just guess. In some cases the package can be isolated by clipping a package lead. This must be done with great care to avoid undue mechanical strains on the board pad or the package. Figure 7 illustrates the removal method. Again, the lowest soldering iron temperature must be used. Caution must be used to avoid serious damage to the board.

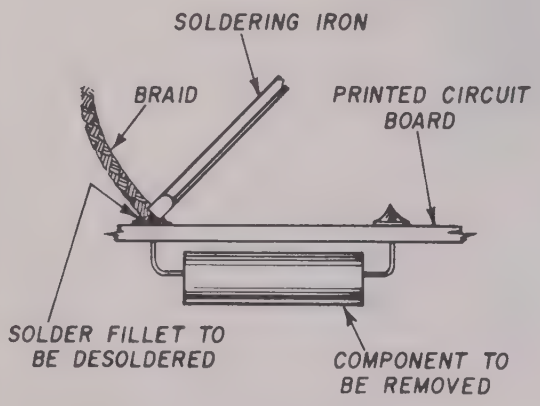


Clean holes with a piece of .020 stainless steel wire by melting the solder and poking the wire through.

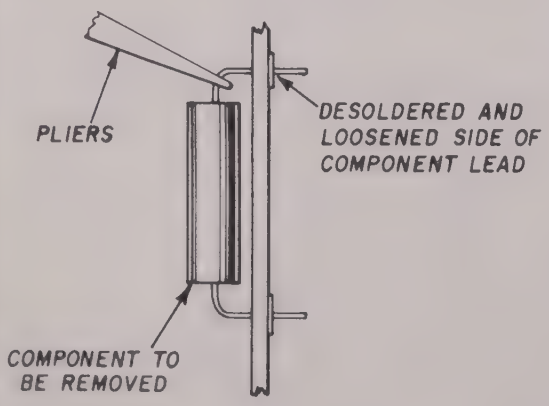
Figure 7.

PROCEDURE FOR REPLACING COMPONENTS IN PRINTED CIRCUIT BOARDS

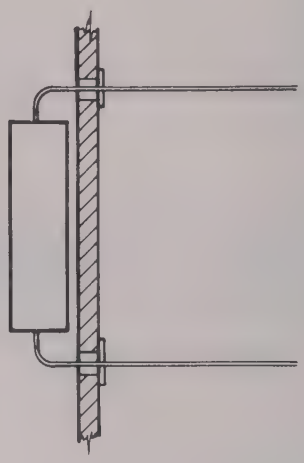
1. Place printed circuit in the horizontal position with the soldered side up. Take a length of fine braid or fine stranded wire either tinned or not tinned. Braid is preferable. Dip the end of the braid in resin flux (London Chemical Co. type #77-33-TA or equivalent). Place the fluxed end of the braid on a solder fillet of the component to be removed. Press the braid on to the fillet using the clean tip of the soldering iron. Do not overheat the board or component. Only heat the solder fillet sufficient to melt the solder. The solder will "wick" up the braided wire removing the solder from the joint. Continue this process until all leads of the component to be removed are free of solder.



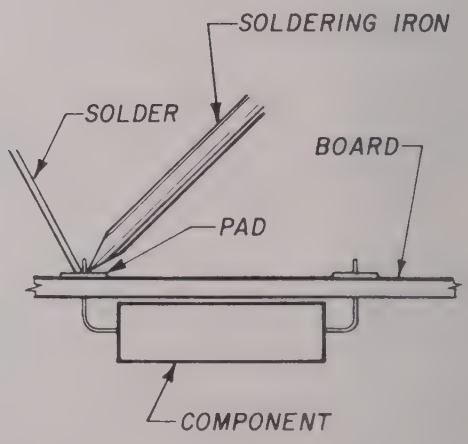
2. Using a pair of needle nose pliers "wiggle" each lead of the component to be removed to be sure it is free of the land area to which it was soldered. Place the needle nose pliers on the component lead and remove the lead. Continue the procedure with each component lead until the component is removed. Do not force the leads. If a lead can not be removed touch the lead on the soldered side of the board with the soldering tip.



3. Bend clean tinned leads of new component and carefully insert in holes. (Do not force component. If it does not insert easily reheat pad and clean as before).



4. Hold part to board and solder leads from print side of board. Do not leave a large blob of solder on pad. The correct amount can be determined by observing other connections made in production.



The above should be carefully followed or extensive damage to the printed circuit board will result.

Figure 8 Servicing Etched Circuit Boards

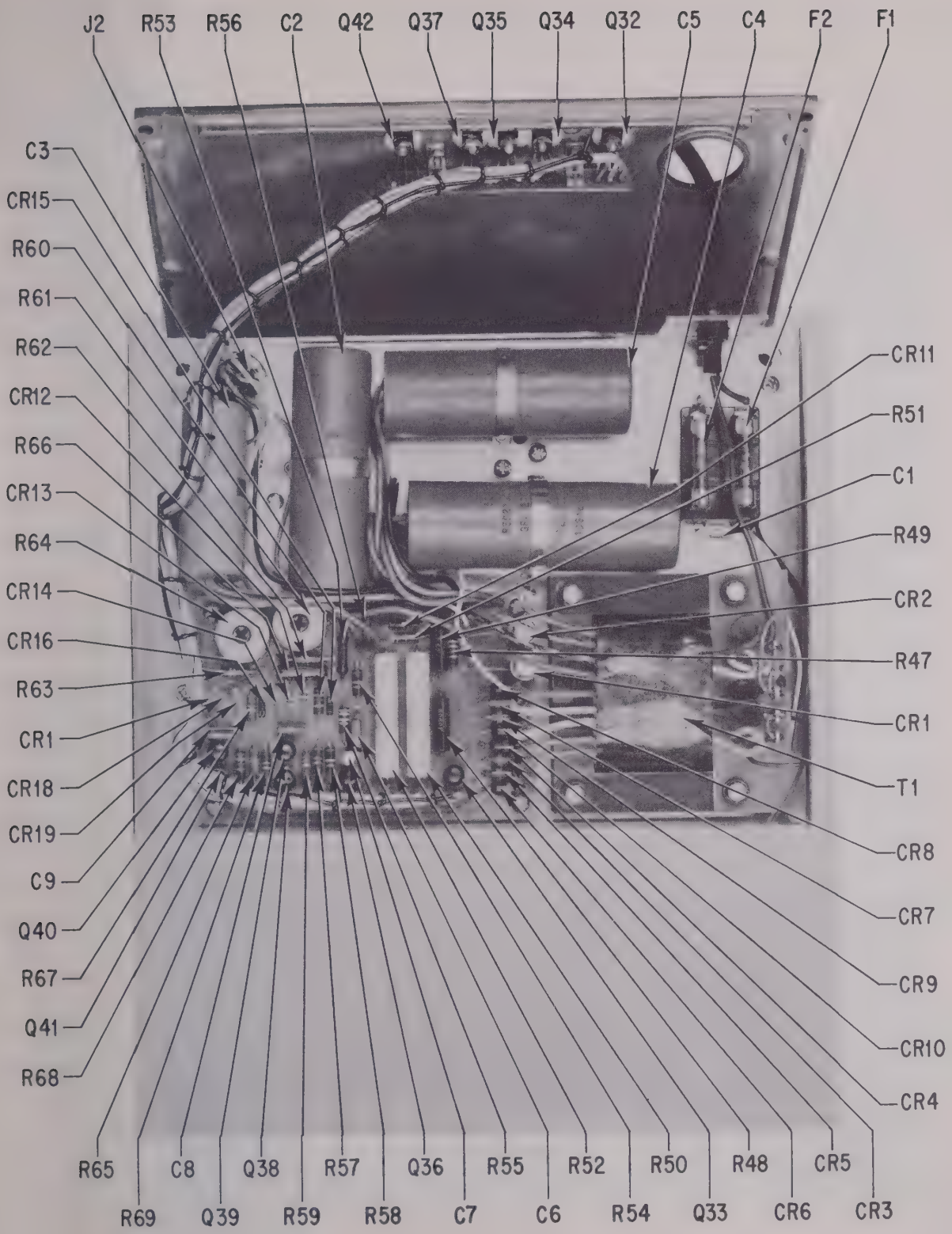


Figure 9 Component Locations -- Power Supply

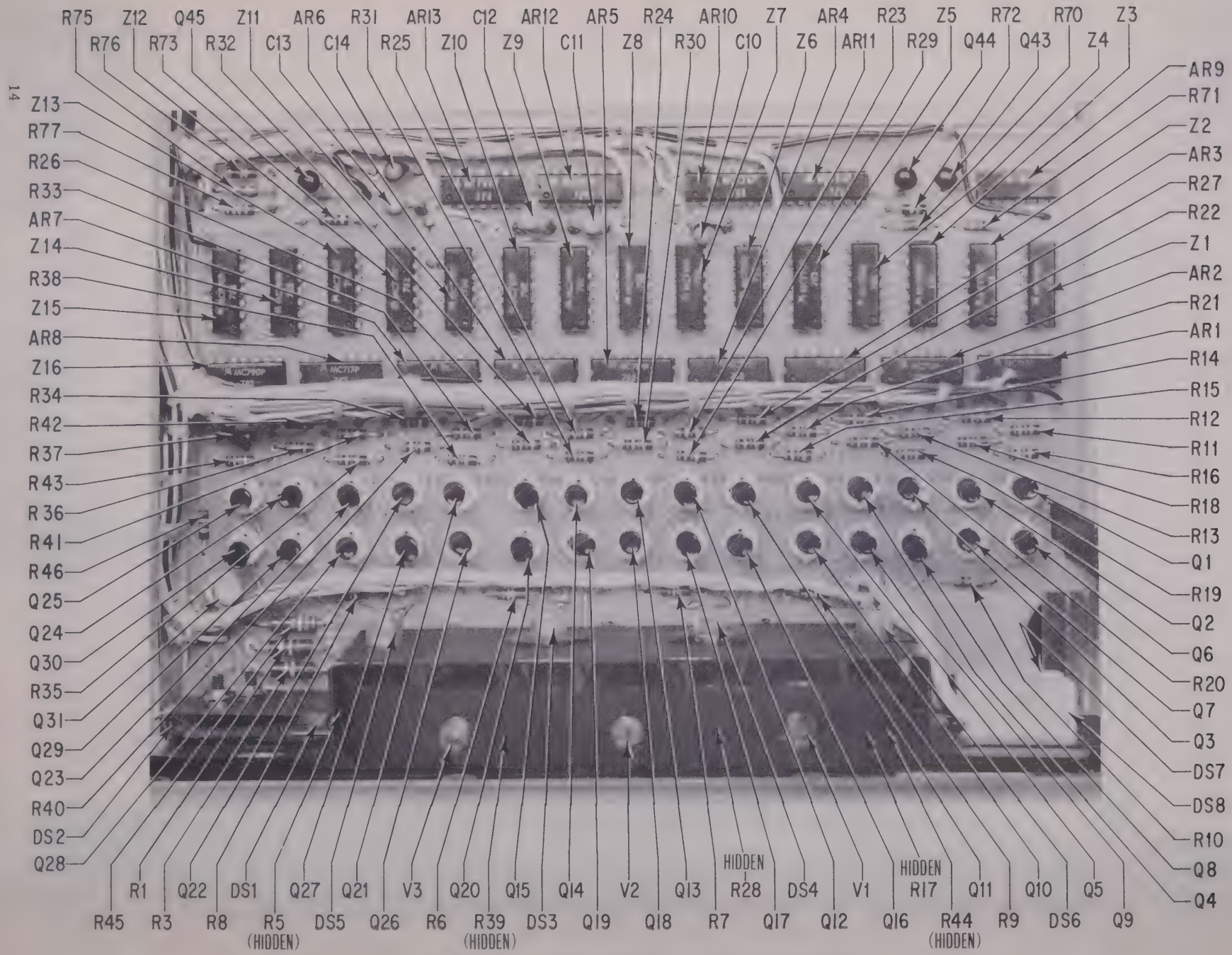


Figure 10 Component Locations -- Main Counter Board

IV
PARTS LIST

Reference designations have been assigned to identify all parts used in this instrument. An asterisk designates a part which should be replaced by authorized Hickok repair stations or factories. It is therefore recommended that the entire instrument be returned for repair if trouble exists with such a part.

In ordering parts, refer to the current parts price list for this instrument. Prices are subject to change without notice, and the minimum billing charge is $3.50.

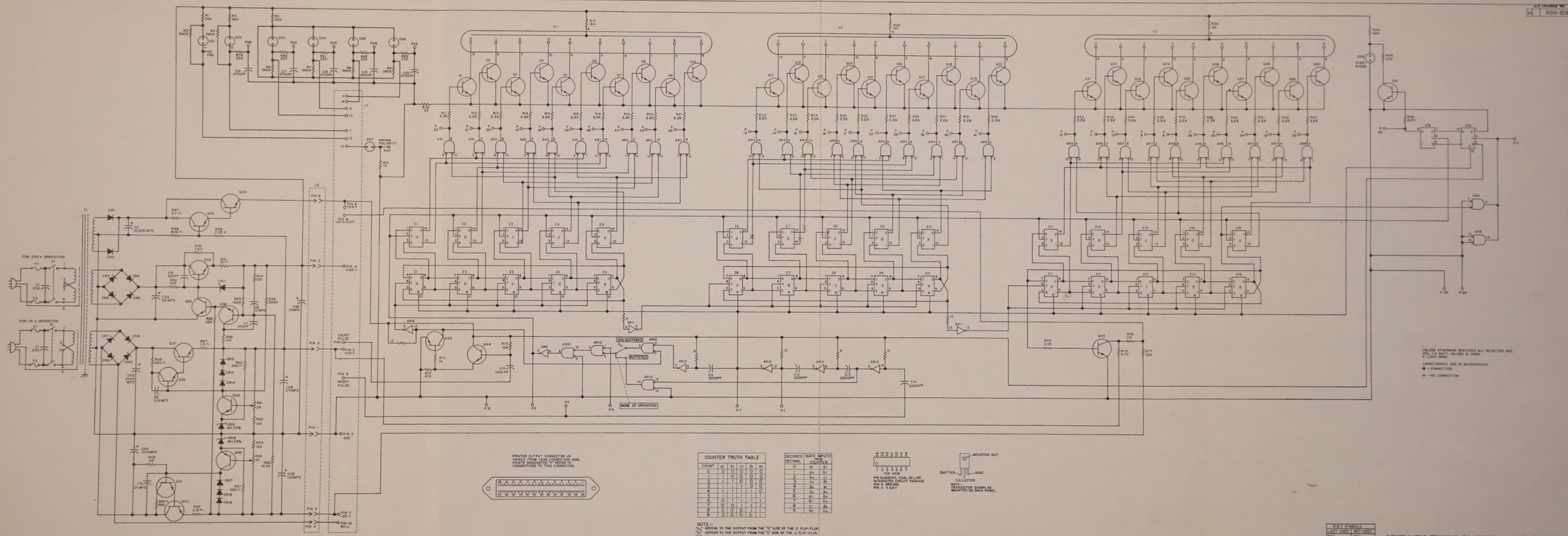
REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.
AR1 thru AR7	INTEGRATED CIRCUIT: quad, 2-input gate	9800-2
AR8	INTEGRATED CIRCUIT: quad, 2-input gate	9800-6
AR9	INTEGRATED CIRCUIT: dual buffer amplifier	9800-3
AR10	Same as AR8	
AR11 thru AR13	Same as AR9	
C1	CAPACITOR, FIXED, POLYESTER FILM: .033uf, 10%, 400 volts	3092-407
C2	CAPACITOR, FIXED, ELECTROLYTIC: 10,000 uf, 12 volts	3085-314
C3A & B	CAPACITOR, FIXED, ELECTROLYTIC: 50 uf @ 300V and 10 uf @ 300V, dual	3085-313
C4A & B	CAPACITOR, FIXED, ELECTROLYTIC: 2700 uf @ 30V and 270 uf @ 30V, dual	3085-311
C5A & B	CAPACITOR, FIXED, ELECTROLYTIC: 1000 uf @ 30V and 100 uf @ 30V, dual	3085-312
C6	CAPACITOR, FIXED, POLYESTER FILM: .1 uf, 10%, 200 volts	3103-30
C7	CAPACITOR, FIXED, CERAMIC: 470 pf, 20%, 500 volts	3111-520
C8, C9	CAPACITOR, FIXED, POLYESTER FILM: .01 uf, 10%, 200 volts	3103-39
C10	CAPACITOR, FIXED, CERAMIC: 1000 pf, +50% -20%, 500 volts	3111-522
C11 thru C13	CAPACITOR, FIXED, CERAMIC: 2200 pf, +50% -20%, 500 volts	3111-524
C14	Same as C10	
C15	CAPACITOR, FIXED, CERAMIC: 220 pf, 20%, 500 volts	3111-518
CR1, CR2	SEMI-CONDUCTOR DEVICE: rectifier, silicon	3870-183
CR3 thru CR6	SEMI-CONDUCTOR DEVICE: rectifier, silicon	3870-158
CR7 thru CR10	SEMI-CONDUCTOR DEVICE: rectifier, silicon	3870-62
CR11	SEMI-CONDUCTOR DEVICE: zener diode	3870-208
CR12 thru CR14	SEMI-CONDUCTOR DEVICE: diode, silicon	3870-175
CR15, CR16	SEMI-CONDUCTOR DEVICE: zener diode	3870-184
CR17 thru CR19	Same as CR12	
DS1, DS2	LAMP: neon indicator NE2H	12270-72
DS3 thru DS6	LAMP: pilot light for decimal points neon source	12270-71
DS7	LAMP: readout, "Wrong Polarity"	12270-69
DS8	LAMP: readout, "Over Range"	12270-68
F1, F2	FUSE: 1 Amp, SLO-BLO	6900-5
Q1 thru Q30	TRANSISTOR: A130	20861-77
Q31	TRANSISTOR: A130-1	20861-78
Q32	TRANSISTOR: MJE-520	20861-129
Q33	TRANSISTOR: 2N3566	20861-122
Q34, Q35	TRANSISTOR: SJE205	20861-135
Q36	Same as Q33	
Q37	Same as Q32	
Q38, Q39	Same as Q33	
Q40, Q41	TRANSISTOR: 2N3638	20861-65
Q42	TRANSISTOR: MJE-370	20861-128
Q43 thru Q45	TRANSISTOR: 2N5130	20861-171
R1	RESISTOR, FIXED: 56K ohms, 10%, 1/2 watt	18413-562
R2	RESISTOR, FIXED: 560K ohms, 10%, 1/4 watt	18454-562
R3	Same as R1	
R4	Same as R2	
R5	Same as R1	
R6 thru R9	Same as R2	
R10	RESISTOR, FIXED: 1K ohms, 10%, 1/4 watt	18452-102
R11 thru R16	RESISTOR, FIXED: 2200 ohms, 10%, 1/4 watt	18452-222
R17	RESISTOR, FIXED: 15K ohms, 10%, 1/2 watt	18413-152
R18 thru R27	Same as R11	
R28	Same as R17	
R29 thru R38	Same as R11	
R39	Same as R17	

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.
R40 thru R43	Same as R11	
R44	Same as R1	
R45	RESISTOR, FIXED: 27K ohms, 10%, 1/2 watt	18413-272
R46	Same as R11	
R47	RESISTOR, FIXED: 4.7 ohms, 10%, 1/2 watt	18525-937
R48	RESISTOR, FIXED, METAL FILM: 806 ohms, 1%, 1/2 watt	18525-939
R49	RESISTOR, FIXED, METAL FILM: 2.32K ohms, 1%, 1/2 watt	18525-938
R50	RESISTOR, FIXED, WIRE WOUND: 7.5K ohms, 10%, 10 watt	18575-504
R51	RESISTOR, FIXED: 91 ohms, 5%, 1/2 watt	18410-911
R52	RESISTOR, FIXED, WIRE WOUND: 10K ohms, 10%, 10 watt	18575-507
R53	RESISTOR, FIXED, METAL FILM: 162K ohms, 1%, 1/2 watt	18525-865
R54	RESISTOR, FIXED: 10K ohms, 10%, 1/2 watt	18413-102
R55	RESISTOR, FIXED: 390K ohms, 10%, 1/2 watt	18414-392
R56	RESISTOR, FIXED: 22K ohms, 10%, 1/2 watt	18413-222
R57	RESISTOR, FIXED: 1.2 ohms, 10%, 1/2 watt	18525-816
R58	Same as R54	
R59	RESISTOR, FIXED: 560 ohms, 10%, 1/2 watt	18411-562
R60	RESISTOR, FIXED: 680 ohms, 10%, 1/2 watt	18411-682
R61	RESISTOR, VARIABLE, WIRE WOUND: 2K ohms	16925-568
R62, R63	RESISTOR, FIXED: 12K ohms, 10%, 1/2 watt	18413-122
R64	Same as R61	
R65	Same as R17	
R66	RESISTOR, FIXED, METAL FILM: 18.2K ohms, 1%, 1/2 watt	18525-868
R67, R68	Same as R60	
R69	RESISTOR, FIXED: 2.2 ohms, 10%, 1/2 watt	18525-819
R70	RESISTOR, FIXED: 4.7K ohms, 10%, 1/4 watt	18452-472
R71	Same as R10	
R72	RESISTOR, FIXED: 10K ohms, 10%, 1/4 watt	18453-102
R73	Same as R11	
R74	Not used	
R75	Same as R70	
R76	Same as R72	
R77	RESISTOR, FIXED: 33K ohms, 10%, 1/4 watt	18453-332
R78	RESISTOR, FIXED: 22 ohms, 10%, 1/4 watt	18450-102
S1	SWITCH: rocker type DPST	19911-91
S2	SWITCH: slide, mode	19911-45
T1	TRANSFORMER: power	20800-348
V1 thru V3	TUBE: nixie, with amber coating	20875-271
Z1 thru Z16	INTEGRATED CIRCUIT: dual J-K flip-flop	9800-1
	BOOKLET: instructions	2490-569

ADD TO DMS-3200P PARTS LIST

C16 thru C20	CAPACITOR, FIXED, CERAMIC: 4700 pF, +50 -20%, 500 volts	3111-526
R79 thru R83	RESISTOR, FIXED: 22K ohms, 5%, 1/4 watt	18470-223

A.T. DRAWING NO.
H 900-213W



PRINTER OUTPUT CONNECTOR J3
VIEWED FROM LEAD CONNECTOR SIDE.
LETTERS DESIGNATED REFER TO CONNECTIONS TO THIS CONNECTOR.

COUNTER TRUTH TABLE					
COUNT	a_1	b_1	c_1	d_1	e_1
0	0	0	0	0	0
1	1	0	0	0	0
2	1	1	0	0	0
3	1	1	1	0	0
4	1	1	1	1	0
5	1	1	1	1	1
6	0	1	1	1	1
7	0	0	1	1	1
8	0	0	0	1	1
9	0	0	0	0	1

DECODED DECIMAL	GATE INPUTS FROM COUNTER	
0	a_1	e_1
1	a_2	b_1
2	b_2	c_1
3	c_2	d_1
4	d_2	e_1
5	a_2	b_2
6	a_1	b_2
7	b_1	c_2
8	c_1	d_2
9	d_1	e_2

NOTE—
"a_1" REFERS TO THE OUTPUT FROM THE "0" SIDE OF THE a FLIP-FLOP.
"b_1" REFERS TO THE OUTPUT FROM THE "1" SIDE OF THE b FLIP-FLOP.
"0" STATE DEFINED BY A LOW VOLTAGE, APPROX. 0.2 VOLTS.
"1" STATE DEFINED BY A PLUS VOLTAGE, APPROX. 13 VOLTS.
P AND J NUMBERS REFER TO CONNECTOR PINS. CIRCLED NUMBERS INDICATE PACKAGE PIN NUMBERS.
AR AND Z NUMBERS REFER TO THE PACKAGE NUMBER.
RESISTORS WITHOUT R NUMBERS, SHOWN WITH AR9, AR11, AR12 AND AR13 ARE INTERNAL TO THE PACKAGE.

NOTE—
TRANSISTOR SHOWN AS MOUNTED ON BACK PANEL.

R.M.C. SYMBOLS	
LAST USED	NOT USED
RC5	RN
RL5	
MF5	
055	

SCHEMATIC WIRING DIAGRAM — Model DMS-3200P